

Retinal Image Multimodal and Multitemporal Registration for a Multispot Laser Photocoagulation Device

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Abstract— This paper aims to assist the physician during the treatment of retinal diseases by laser photocoagulation, aligning images obtained by different acquisition methods in preliminary examinations to the treatment. Thus, an algorithm with combinations and arrangements of related methods was proposed, in order to allow the multimodal recording of retinal images. The proposed algorithm performs the detection of points of interest using SURF, elaborates the characteristic descriptor of each point using a combination of SIFT and PIIFD, eliminates the outliers by means of a Robust Point Matching method via Vector Field Consensus (VFC) and finally performs the registration with the Geometric Transformation of the type Affine. The algorithm was tested in 40 pairs of multimodal retinal images and performed better when compared to existing algorithms in terms of precision and robustness.

Keywords—multimodal registration, local feature, SIFT, multispot laser, partial intensity invariance, retina images, robust point machine, SURF, PIIFD, VFC.

I. INTRODUCTION

Total or partial loss of vision and age-related diseases impact on economic and educational opportunities, reduce quality of life and increase the risk of death [1]. According to studies published in 2017 [2], globally it is estimated that there are 36 million blind people, 216.6 million people had moderate to severe visual impairment (MSVI – *Moderate and severe visual impairment*) and 188.5 million had mild visual impairment. It is also estimated that approximately 80% of visual impairments are considered treatable and can be prevented. More, the blindness causes were: 33% cataract, 21% incorrect refractive error and 5% macular degeneration. For MSVI, 53% incorrect refraction, 18% cataract and 3% macular degeneration [3].

The retina is one of the membranes of the posterior segment of the eye, and has the function of transforming the light stimulus in a nerve stimulus so that the images can be read. It is capable of delivering an impressive image definition with clarify and vivid colors, beyond the precise focus. Early diagnosis of diseases in the retina can delay and even interrupt the progression of the disease in the patient. Through photographs that record the fundus of the eye, it is possible visualize vascular anomalies, bleeding, small aneurysms, proliferation of vessels, among others. This analysis of the retina is very important to prevent, diagnose and treat eye diseases and can cause irreversible damages, like glaucoma, diabetic retinopathy, age-related macular degeneration, diabetic macular edema, pathological myopia, venous retinal occlusion, etc.

More and more technology is developing in the health area, in order to assist the professional in the diagnosis of the disease and in the treatment, being able to prevent or cure these diseases in the eyes. The ophthalmologic area was the first medical specialty to use the laser for the human treatments. In 1961, Koester and Cambell used a laser prototype for tumor photocoagulation in the retina. From this time on, studies and research in the field of laser technology applied to the retina have progressed greatly, since the photocoagulation treatment can be applied to retina diseases as mentioned above, and can prevent, delay or cure lesions [4].

The image processing incorporated into ophthalmic equipment for photocoagulation can optimize and assist the physician in the procedure of treating the lesions in the retina of the patient. Intelligent retinal scanning systems enable the application of multiple pulses, reduce treatment time, patient pain and increase application accuracy. The improvement of software, the use of communication networks, the expansion of the use of the digital language should allow a greater exploration of the images obtained in the examination equipment, offering more information for the control and treatment of diseases of the retina and vitreous.

This work aims to improve and develop computer vision techniques applied to ophthalmic devices that have the function of multiple laser shots for retinal photocoagulation. So, it will enable the physician to analyze the retina of the patient prior to the treatment date, planning the retinal targets that should receive the photocoagulation based on images obtained by different acquisition methods in preliminary examinations to the treatment.

II. METHODS

A. Image Database

For the execution of this work, we used images obtained by equipment able to photograph the fundus of the eye, the retina. The images belong to the database of the manufacturer of the fundus camera, which kindly gave the images for the elaboration of this work.

This database is composed of fundus of the eye images of the different acquisition methods supported by the equipment. The types of images are:

- Fluorescein angiography (FA), which uses a contrast agent called fluorescein that is applied to the patient's bloodstream at the time of examination, providing greater detail of the retinal vessels. The